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Seasonal Movements and Habitat Selection by Woodland Caribou in the Wolverine Herd, North-central British Columbia
Phase 2: 1994-1997

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1.0 INTRODUCTION

Conflicts associated with maintaining woodland caribou populations and forest harvesting have focused most habitat use studies on the mountain caribou ecotype residing in the southeast part of the province (Stevenson and Hatler 1985, Antifeau 1987, Seip 1990, Seip 1992, Terry et al. 1996). Mountain caribou inhabit areas of deep snowpacks in winter, forcing them to forage primarily on arboreal lichens in high elevation forests (Stevenson and Hatler 1985). With increasing demands for forest products throughout the province, and decreasing availability of these resources, the concern has shifted to include caribou populations in the northern part of the province. The northern caribou ecotype resides in areas with low to moderate snowdepths (<1 m), and forages primarily on terrestrial lichens in winter in low elevation commercially valuable forests. To date, only two major studies in the province have focused on the northern caribou ecotype (Hatler 1986; Cichowski 1989); only the latter study was related to forest harvesting concerns.

There are two woodland caribou populations residing on the west side of the Williston Reservoir (Wood 1996). The Chase Caribou Herd (CCH) was estimated at between 400 and 1,100 animals based on a 1993 mark-resight winter inventory (Wood 1996). The Wolverine Caribou Herd (WCH) was estimated at between 260 and 560 caribou during a March 1996 mark-resight winter inventory (Wood 1998).

With the creation of the Williston Reservoir in north central B.C. in the late 1960s, an extensive area (1,770 km^2) of wildlife habitat and forest resources was flooded, placing increased pressure for these resources on surrounding lands. Both the Chase and Wolverine Herds are faced with substantial increases in forest harvesting over the next ten to twenty years which will result in increased road development, reduced amounts of mature forests, and potential fragmentation of the larger regional landscape. Therefore, detailed information on caribou habitat use was required to make better informed decisions with respect to the management of both forests and caribou in this area. This information will assist resource managers with current land-use planning initiatives (e.g., Mackenzie Land and Resource Management Plan), and in designing a caribou/forestry management strategy for the area.

To address these concerns, the Omineca Mountains Woodland Caribou Project was initiated in 1991 and was completed in two phases. The objectives of Phase 1 were to

determine seasonal movements, habitat selection patterns, population status and distribution of caribou residing along the west side of the Williston Reservoir. Phase 1 included monitoring of radio-collared caribou in both the Chase and Wolverine Caribou Herds between 1991-1994 (Wood 1996, Wood and Terry 1999). Phase 2 was initiated in April 1994 for an additional three year period (1994-1997), and focused on the use of forested habitats by caribou in the Wolverine Herd. The primary objective of this report was to describe seasonal habitat selection and movement patterns of the Wolverine Herd between 1994-1997.

2.0 STUDY AREA

The seasonal ranges of the Wolverine Caribou Herd (WCH) lie within the Omineca Mountains on the west side of the Williston Reservoir in north central B.C. (Figure 1). At elevations below 1100 metres, the Sub-Boreal Spruce (SBS) in the southern part of the study area gives way to the Boreal Black and White Spruce (BWBS) in the north (Meidinger and Pojar 1991). Variants include the Mossvale moist cool SBSmk1, Williston moist cool SBSmk2, Finlay-Peace wet cool SBSwk2, and the Stikine dry cool BWBSdk1 (MacKinnon *et al.* 1990, DeLong *et al.* 1993). These biogeoclimatic zones have histories of extensive wildfire (Parminter 1984), and support forests dominated by lodgepole pine *(Pinus contorta)* and white spruce *(Picea glauca)*. The Omineca moist very cold Engelmann Spruce Subalpine Fir (ESSFmv3) zone is found at elevations between 900 and 1,600 metres (MacKinnon *et al.* 1990); climax tree species in the ESSF include the Engelmann spruce *(Picea engelmannii)* and subalpine fir *(Abies lasiocarpa)*. Extensive lodgepole pine stands in the ESSF are uncommon as wildfires are less frequent. Alpine Tundra (ATp) exists at the highest elevations throughout the study area, extending between 1,550 and 2,100 metres. Gentle, windswept alpine slopes are common.

The range of the WCH encompasses one primary mountain range in the east (the Wolverine Range) and a few smaller alpine ranges to the south and west (Figure 1). The Omineca River valley cuts through the range of the caribou: downstream of Germansen Landing, the river is bordered by southeast facing aspen slopes to the west, with extensive lodgepole pine flats to the east. Upstream of Germansen Landing, the river floodplain broadens (meandering river, extensive willow, and meadows). In the southern part of the WCH range is a broad expanse of low elevation (1,000 - 1,300 m) ESSF forest

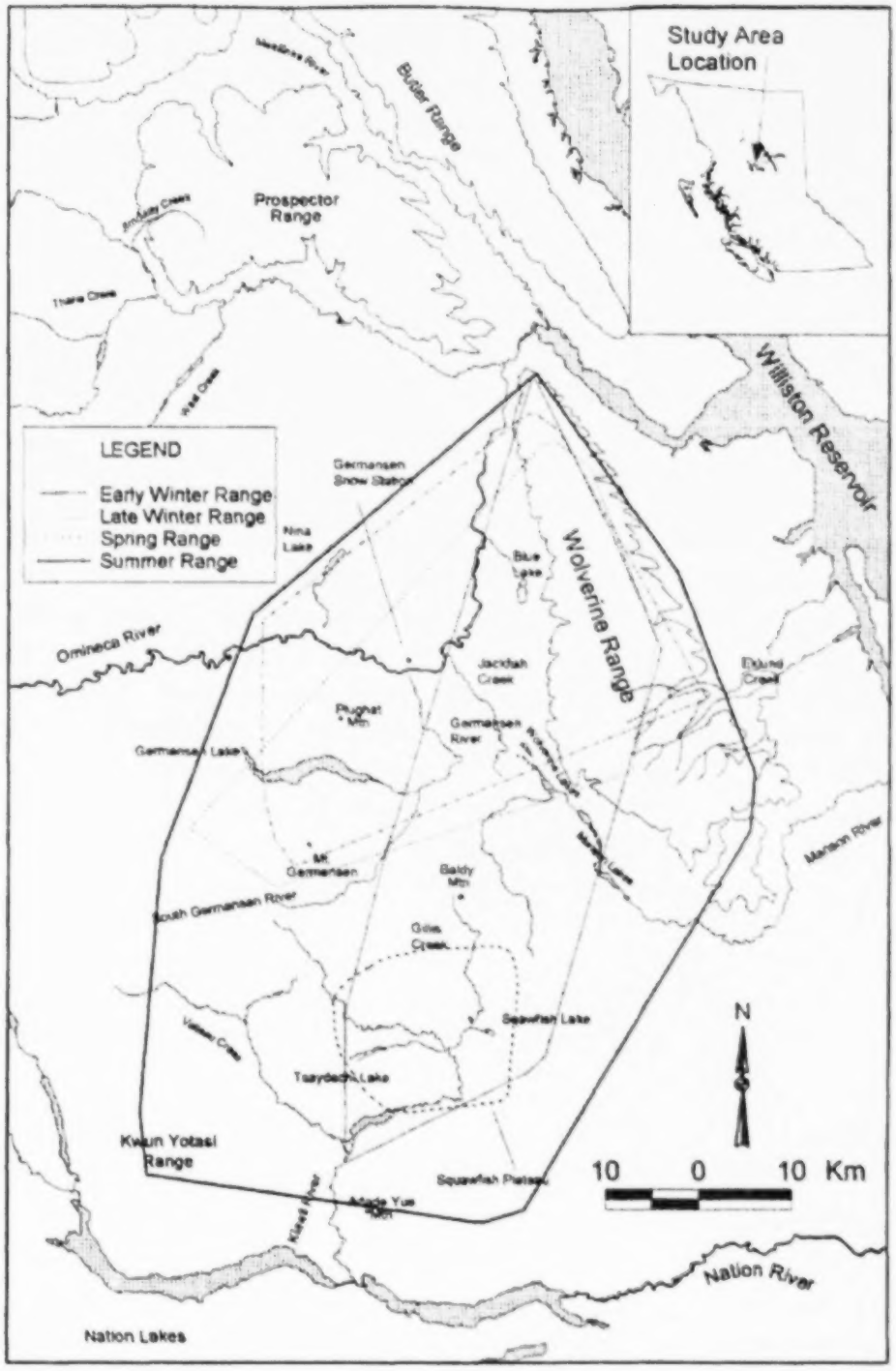

Figure 1. Location of the Wolverine Caribou Herd west of the Williston Reservoir. Boundary represents the multi-year annual home range (1994-97).

(predominantly lodgepole pine with some white and black spruce) interspersed with numerous meadows and small lakes ("Squawfish Plateau").

To date, forest harvesting activities in the WCH range have been minimal and are concentrated on the east and south sides of the Wolverine Range, primarily at low elevations. Some harvesting has also occurred along the east side of the Wolverine Range in the ESSF zone. The Omineca River valley remains intact, as does the Squawfish Plateau.

The Omineca River valley provides some of the best winter range for moose *(Alces alces)* in the Williston watershed which is the only other common ungulate in the area. Other ungulates present in much smaller numbers include mountain goat *(Oreamnos americanus),* mule deer *(Odocoileus hemionus),* white-tailed deer *(Odocoileus virginianus),* and elk *(Cervus elaphus).* Potential predators of caribou include wolf *(Canis lupus),* wolverine *(Gulo gulo),* grizzly bear *(Ursus arctos),* black bear *(Ursus americana),* and lynx *(Lynx canadensis).*

3.0 METHODS

3.1 Capture and Radio-Collaring

Caribou were captured using a hand-held net-gun fired from a Bell 206 Jet Ranger helicopter, and fitted with radio-collars equipped with mortality sensors (Model LMRT-4, Lotek Engineering). Twenty-seven (18F, 9M) radio-collared caribou were monitored during Phase 2. Seventeen of these caribou were captured and collared between 1994-1997. During this period, 5 males were captured on the Wolverine Range in March 1994, 4 females and 2 males on the Squawfish Plateau in November 1995, and 4 females and 2 males on the Wolverine and Germansen Ranges in February/March 1996. The remaining 10 caribou monitored during Phase 2 were collared during Phase 1: 4 females and a male in 1991, 4 females in 1992, and 1 female in 1993 (Wood and Terry 1999).

3.2 Radio-Telemetry

Radio-tracking flights were conducted approximately biweekly during the winter, and monthly during the summer, over a 3 year period: 94/95 (April 1994 - March 1995), 95/96 (April 1995 - March 1996), and 96/97 (April 1996 - March 1997). Most flights were conducted using a Cessna 182 fixed-wing aircraft, a Bell 206 helicopter was also used on occasion.

Site characteristics (e.g. tree species, slope, aspect) and group size, were recorded for each radio-collared caribou located. Latitude and longitude for each caribou location were obtained from the on-board Global Positioning System (GPS) unit. Locations were then plotted on 1:250,000 and 1:50,000 topographic maps, and 1:50,000 British Columbia Forest Service (BCFS) forest cover maps, and verified in combination with the site and habitat characteristics noted from the air. Elevation was obtained from topographic maps.

3.3 Seasonal Movements and Home Ranges

Multi-year home and seasonal ranges were estimated as 100% Minimum Convex Polygons (MCP; Mohr 1947) and calculated using Ranges V computer program (Kenward and Hodder 1996). Multi-annual ranges were calculated using all radio-locations of all collared caribou during the three year study period. To determine individual home range size, multi-annual home ranges were calculated for each individual caribou with at least 20 radio-locations.

Six seasons were initially defined based primarily on elevational shifts and movement patterns that included:

1) Spring (1 April - 15 May)
2) Calving (16 May - 15 June)
3) Summer (16 June - 15 Sep)
4) Fall/Rut (16 Sep-30 Oct)
5) Early Winter (1 Nov - 30 Dec)
6) Late Winter (1 Jan - 31 Mar)

However, to facilitate the habitat analysis (see below), calving, summer and rut periods were grouped together as one summer season (16 May - 30 Oct). Despite the grouping of these time periods, it should be noted that 126 of 179 (70%) of the summer locations represented the calving season.

Fidelity to seasonal ranges (e.g. calving areas, early winter range) was defined to include those caribou that consistently returned to a similar geographic location (within a 5 km radius) in consecutive years. The summary of fidelity to calving areas includes all calving locations for radio-collared female caribou monitored during both Phase 1 (1991-1994; Wood and Terry 1999) and Phase 2 (1994-1996; this report). Of the 10 caribou monitored during both Phases, 6 were monitored for 5 years, 3 for 4 years, and 1 for 3 years.

3.4 Habitat Analysis

Forest cover map descriptions were grouped into seven forest cover types based primarily on tree species composition (Table 1). Because a minimum of five observed and expected locations is typically recommended for reliable statistical tests (Manly *et al.* 1993 and others) we grouped mature (81-120 years old) and old (>120 years old) stands leading in lodgepole pine to represent potential winter terrestrial lichen feeding habitats. In addition, 60-80 year old lodgepole pine stands were grouped with the 'other' category that included predominately immature conifer stands (only 4 of 756 caribou locations occurred in this habitat type). These age classes are believed to provide little lichen biomass (D. Coxson, University of Northern BC, personal communication) and therefore were considered immature with respect to terrestrial lichen abundance. These groupings helped minimize the number of habitat types and reduced the probability of TYPE II errors (Alldredge and Ratti 1986).

All caribou location co-ordinates were entered into ARC/INFO Geographic Information System, and each radio-location was placed into one of the seven habitat types. The proportion of radio-collared caribou locations in each habitat type was determined for each of the four seasons. Small sample sizes required the pooling of individual locations across years to increase cell frequencies. Male caribou demonstrated similar seasonal habitat use patterns to females ($P > 0.05$), therefore, we grouped females and males for all analyses.

Table 1. Description of forest cover types available to woodland caribou in the WCH.

Forest Cover Type	Description
Alpine/subalpine	Treeless ridge tops and open subalpine areas supporting scattered subalpine fir, also low stocking/inoperable timber types
Balsam	Mature and old (80+ years) stands leading in subalpine fir
Spruce	Mature and old (80+ years) stands leading in white or Engelmann spruce
Pine	Mature and old (80+ years) stands leading in lodgepole pine
Mixed Deciduous	Forested stands leading in aspen (all ages), or mixed conifer/deciduous where the aspen component $\geq$ 20% e.g., P1A, P1SA
Fen/Wetland	Wetland complexes, bogs, fen meadows, and open water (i.e., lakes)
Other	Mostly immature stands including conifer stands <80 years old, burns, clearcuts (NSR)

We estimated seasonal habitat availability using the 100% minimum convex polygon (MCP) method (Mohr 1947). The multi-annual herd home range boundary (see "Home Ranges" descriptions) was used to represent proportions of habitats available to the herd over the entire study area. The proportion of each of the seven different habitat types within the WCH's multi-annual and four multi-annual seasonal ranges was determined using ARC/INFO GIS. Appendix 2 depicts the forest cover types available within the Wolverine Herds' multi-annual home range.

Radio-locations were also placed into one of three elevation categories (7,00-1,100 m, 1,101-1,500 m, >1,500 m) which roughly corresponded to broad biogeoclimatic subzones (BWBS/SBS, ESSF and AT respectively). In addition, we grouped radio locations into one of two aspect categories (cool NW-SE, warm SE-NW), and one of three slope categories (0-15%, 16-30%, >30%). Because we did not measure availability of these topographic attributes, this analysis was confined to seasonal use comparisons.

Chi-square analysis (log-likelihood ratio, G-test) was used to test for differences in forest cover use among seasons. To determine second-order selection (Johnson 1980), the estimated amount of each forest cover type that occurred in each seasonal home range, (100% MCP) was compared to the proportions of forest cover types available in the composite annual home range using the *Z* statistic (Zar 1987). To determine third-order

selection, (i.e., selection of habitats within seasonal home ranges), data were analyzed using Chi-square Goodness-of-fit tests because habitat availability were assumed to be known without error (Thomas and Taylor 1990). If the null hypothesis of random habitat use was rejected, Bonferroni simultaneous confidence intervals were applied to selection ratios to determine which habitats were selected or avoided according to the methods of Manly *et al.* (1993). Selection ratios are expressed as

$$\omega_i = o_i/\pi_i$$

where ω_i is the selection ratio for habitat $_i$, o_i is the proportion of use in habitat $_i$ and π_i is the proportion of habitat i estimated to be available.

Approximate simultaneous 100(1 -α)% confidence intervals were calculated using the formula:

$$\omega_i \pm z_{\alpha/2I}\, se(\omega_i)$$

where

$$se(\omega_i) = \sqrt{[(1-\pi_i)/u_+\pi_i)]}$$

I ($Z_{\alpha/2I}$) corresponds to the total number of habitats considered available to the animal and u+ is the total number of use locations. Relative preference and avoidance was inferred if use was significantly greater or less than availability. Selection ratios were ranked from smallest to largest and pairwise comparisons made to determine significant differences between selection ratios (see Manly *et al.* 1993 pg. 48).

Selection ratios can also be standardized so that they sum to 1 using the formula:

$$B_i = \omega_i/\Sigma\,\omega_i$$

Standardized selection ratios have the advantage of not being sensitive to the inclusion of large but seldom used habitats (Manly *et al.* 1993). Pairwise comparisons of selection ratios together with their standardized form were used to rank habitats from most preferred to least preferred and allowed interpretations of habitat selection using relative probabilities. All statistical tests were conducted at α = 0.05. Although small sample sizes precluded a statistical analysis of inter-annual variation in habitat selection patterns, a descriptive account of habitat use by year is presented.

To provide a more quantitative assessment of caribou use of forest/wetland complexes, a brief post-hoc analysis of the linear distance from each caribou radio-location to the nearest wetland was conducted. Distance to the nearest wetland was analyzed using a

two-way ANOVA *(sex and season* factors). Distances were log-transformed before analysis to stabilize variances.

Snow depths were based on BC Environment data from two stations including one high elevation station situated at Germansen (1,500 m) and another mid-elevation station situated at Tsaydachi Lake (1,160 m) (BC Environment, 1994-1997; Figure 1). These stations were selected to best represent snow conditions in the study area.

3.5 *Population Characteristics*

Collared caribou mortalities were located during radio-telemetry flights with the aid of the motion-sensing mortality collar. Three mortalities were investigated on the ground. Although we were unable to provide precise estimates of annual mortality rates due to small sample sizes, we provide a brief descriptive account of caribou deaths over our study period.

Population density was calculated for the Wolverine Caribou Herd by dividing the estimated caribou population by the average annual home range size of the herd (Bergerud 1992). The winter range density was also determined using the population size divided by the average annual late winter range size.

4.0 RESULTS

4.1 Radio-Telemetry

A total of 756 radio locations were obtained over the three year study period (early winter: n =220; late winter: n = 194; spring: n = 163; summer: n = 179). The number of radio-collared caribou monitored varied between 7-13 for females and 2-6 for males during the study (Table 2).

4.2 Seasonal Movement Patterns

Examination of the telemetry data indicated caribou made three relatively long between season movements (20-50 km) throughout the year including: (i) early to mid May as

Table 2. The number of caribou radio-locations obtained for each year, season and sex. The number of radio-collared caribou are shown in brackets.

	94/95		95/96		96/97		Total
Season[†]	Female	Male	Female	Male	Female	Male	
EW	50 (9)	31 (5)	47 (9)	31 (6)	49 (9)	12 (2)	220
LW	42 (7)	24 (4)	40 (12)	21 (6)	53 (8)	14(2)	194
SP	36 (9)	24 (6)	27 (7)	16 (4)	47 (13)	13 (5)	163
SU	27 (9)	14(5)	39(7)	21 (4)	63 (12)	15(3)	179
Total	155	93	153	89	212	54	756

[†] SP= Spring (1 Apr-15 May); SU= Summer (16 May-30 Oct); EW = Early winter (1 Nov-30 Dec); LW = Late winter (1 Jan-31 Mar)

they moved from spring habitats to calving areas (20-45km); (ii) early November as they moved from summer and rut habitats to early winter ranges (20-50 km); and (iii) early December to early January as they moved from the early winter range on the Squawfish Plateau north to the Manson River, Jackfish Creek, Blue Lake or the Germansen Range (20-50 km). Within season movements were generally shorter and varied between 0.5-10 km.

A closer inspection of the early winter data also revealed many of these caribou spent the month of November near Squawfish Lake and the Klawli River. In December, caribou generally moved north towards Baldy Mountain, Mount Gillis and along the headwaters of the Manson and South Germansen Rivers before reaching the Wolverine and Germansen Ranges where they spent the late winter (Figure 2). During spring, caribou were often located in mixed deciduous stands (e.g., aspen slopes) near Germansen Lake, east of the Germansen River and along the lower Omineca River (Figure 3, see Appendix 2). Caribou locations were widely distributed throughout the study area during the summer months (Figure 3). During the calving season, caribou locations occurred most frequently along the southern portions of the Wolverine Range near Eklund Creek, the north end of the Wolverine Range, as well as Plughat Mountain, Germansen Lake, South Germansen River and Manson Lake. Other areas used by some caribou during summer included the Kwun Yotasi Range and Adade Yus Mountain near Nation Lakes (Figure 3).

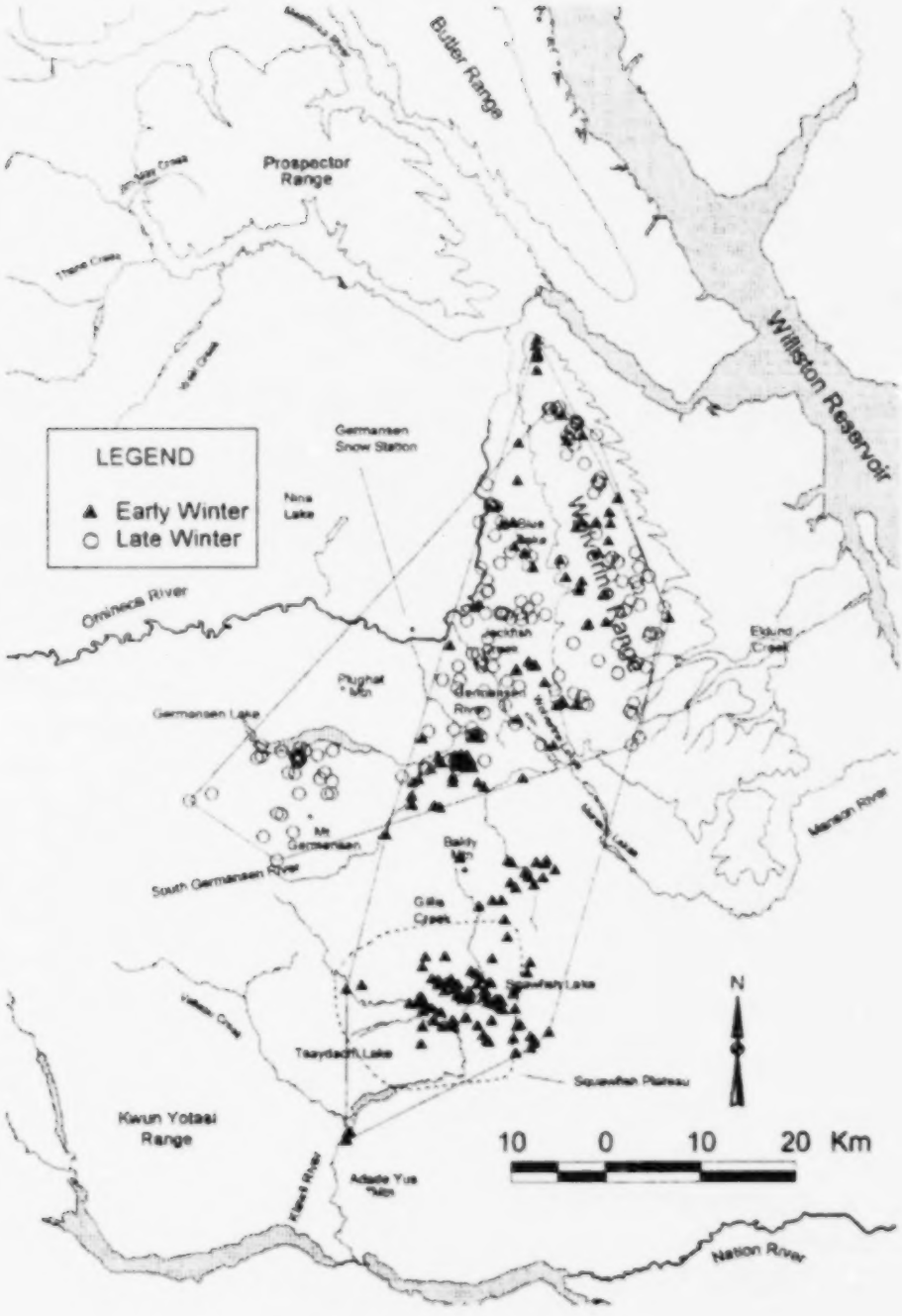

Figure 2. Early and late winter locations of radio-collared caribou in the Wolverine Caribou Herd (1994-97).

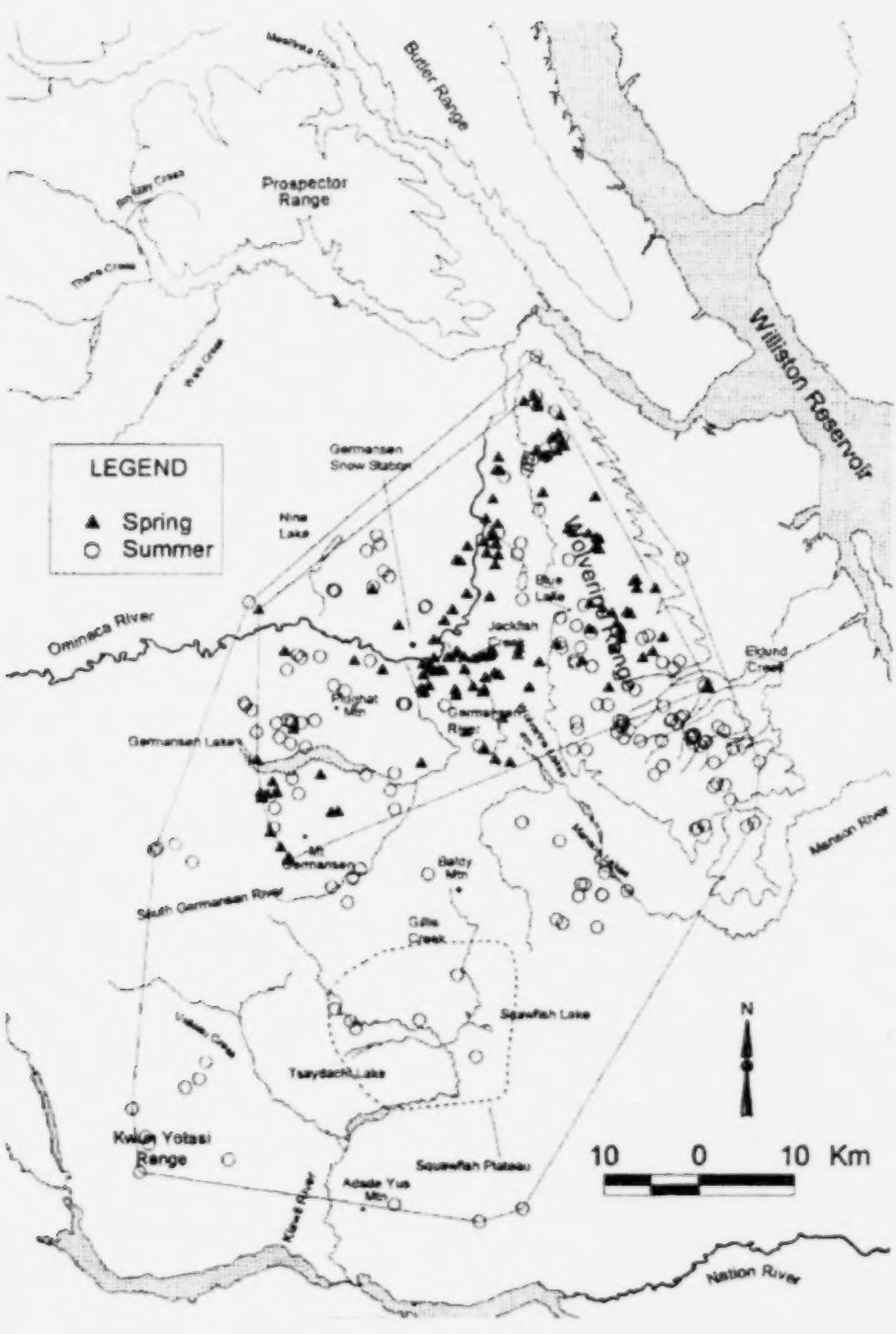

Figure 3. Spring and summer locations of radio-collared caribou in the Wolverine Caribou Herd (1994-97).

4.2.1 Fidelity to Seasonal Home Ranges

Early Winter

Eight of eight (100%) radio-collared female caribou showed fidelity to early winter ranges. These caribou returned each November from summer ranges to the Squawfish Lake area, Klawli River, or the Wolverine Range. Similarly, all male radio-collared caribou (4 of 4) also returned to the same general location by November. These caribou returned each year to the Squawfish Lake area, Tsaydaychi Creek or the Wolverine Range.

Late Winter

Unlike early winter, both female and male caribou showed less fidelity to late winter ranges. Five of nine (56%) female and 2 of 4 male caribou returned to similar late winter areas in either the Wolverine or Germansen Ranges. Most of the other animals that showed a lack of late winter range fidelity appeared to switch between the Wolverine and Germansen Ranges. One female (#524) and one male (#650) caribou spent late winter in a different location in each of the years they were monitored. Female #524 spent the late winter of 1994, 1995 and 1996 in the Germansen Ranges, Jackfish Creek and Manson River areas respectively whereas the male caribou switched between Jackfish Creek, Wolverine Range and the Germansen Range during these years. Both of these caribou showed fidelity to their early winter range (Squawfish Lake /Klawli River).

Calving Season

Most of the 10 radio-collared female caribou monitored during both Phase 1 (1991-94) and Phase 2 (1994-97) appeared to show fidelity to one or two calving areas. Four collared females showed strong fidelity to calving areas, returning to the same area each year. Two of the females used the north end of the Wolverine Range during each of the 4 calving seasons they were monitored. The other 2 (each monitored for 5 years) returned to Eklund Creek headwaters and Plughat Mtn. respectively. Five collared females monitored for 3 (n=1), 4 (n=3), or 5 (n=1) years were found to use two different areas for calving; calf production in both areas used was confirmed for 3 of these females. Calving areas used included the Eklund Creek area, Carmella Creek, Mt. Porter, north end of the Wolverine Range, and Nina Lake. One collared female monitored for 5 years produced a calf in each of the 3 different areas it used during the calving period: Eklund Creek, Mt. Porter, and the north end of the Wolverine Range.

4.2.2 Home Range Size

Mean annual home range size (100% MCP) was similar between male and female caribou (*t*-test, $P = 0.436$) (Table 3).

Table 3. Multi-annual home range size (km2) for female and male caribou in the Wolverine Caribou Herd. 1994-1997.

Caribou ID	Sex	# locations	100% MCP	95% MCP
464	F	61	816	530
443	F	29	866	757
312	F	30	685	647
792	F	33	1,100	992
110	F	46	1,439	1,321
1893	F	27	119	45
781	F	31	825	482
912	F	33	1,200	1,185
515	F	43	1,320	1,309
151	F	23	1,661	1,595
131	F	24	694	689
121	F	20	1,782	1,772
Average Female *(n =13)*			1,124 ±149	982 ± 140
642	M	40	1,168	870
544	M	41	789	737
610	M	61	1,495	1,457
650	M	61	2,150	2,138
Average Male (*n* = 4)			1,400 ±288	1,300± 319

Numbers are means ± 1SE. MCP= Minimum Convex Polygon.

4.3 Seasonal Habitat Use

4.3.1 Elevation

Caribou varied their use of elevation categories among seasons (G = 171.3, df=6, *P* 0.001). During early winter, caribou used mid-elevations (1,101-1,500 m) extensively (75% of locations) (Figure 4). During late winter, caribou increased their use of higher elevations (>1,500 m) from 8% (early winter) to 41% of the locations. Caribou were more evenly distributed among all elevation categories during spring, but increased their use of low elevation areas (35% of locations) compared to other seasons. By summer, caribou returned to using mid-elevation habitats extensively (Figure 4).

4.3.2 Forest Cover Types

Seasonal shifts in elevation also resulted in significant variation in habitat use among seasons *(G* = 212.7, df = 18, P < 0.001). Caribou used primarily lodgepole pine forests (56% of locations) as well as fen/wetland areas (21% of locations) during early winter (Figure 5). Most of these pine forests and wetland areas occurred near Squawfish Lake, Klawli River, Germansen River and Jackfish Creek (Figure 3). During late winter, caribou decreased their use of pine forests and fen/wetland areas and made extensive use

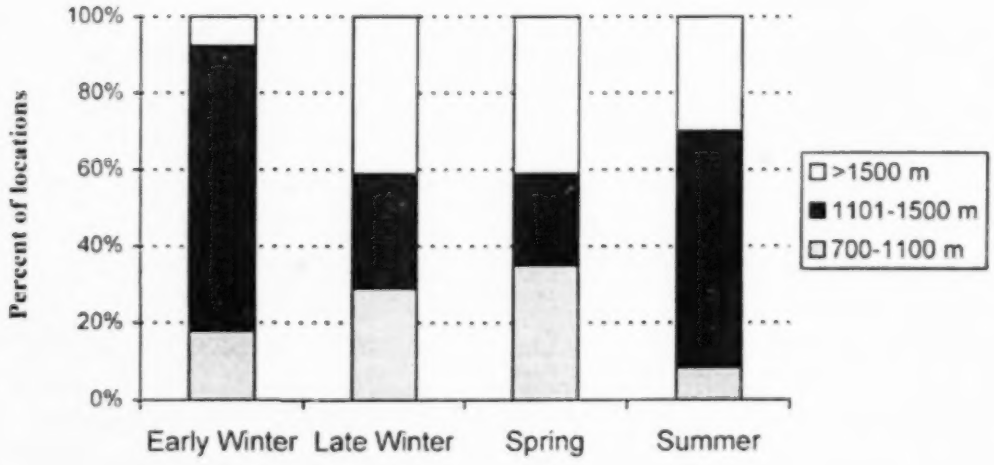

Figure 4. Percent of caribou locations in 3 elevation categories during different seasons. Wolverine Caribou Herd, 1994-1997.

(40% of locations) of alpine and subalpine habitats in the Wolverine and Germansen Ranges (Figures 3, 5). Although caribou continued to use alpine areas during spring, they also used mixed deciduous stands more frequently compared to other seasons (Figure 5). Most of the mixed deciduous stands (e.g., aspen slopes) used by caribou during spring occurred near Germansen Lake, east of the Germansen River and along the lower Omineca River (Figure 2, see Appendix 2). During summer, caribou spaced out widely through the study area and increased their use of balsam (24% of locations) as well as spruce dominated stands, but used pine forests less frequently compared to other seasons (Figure 5).

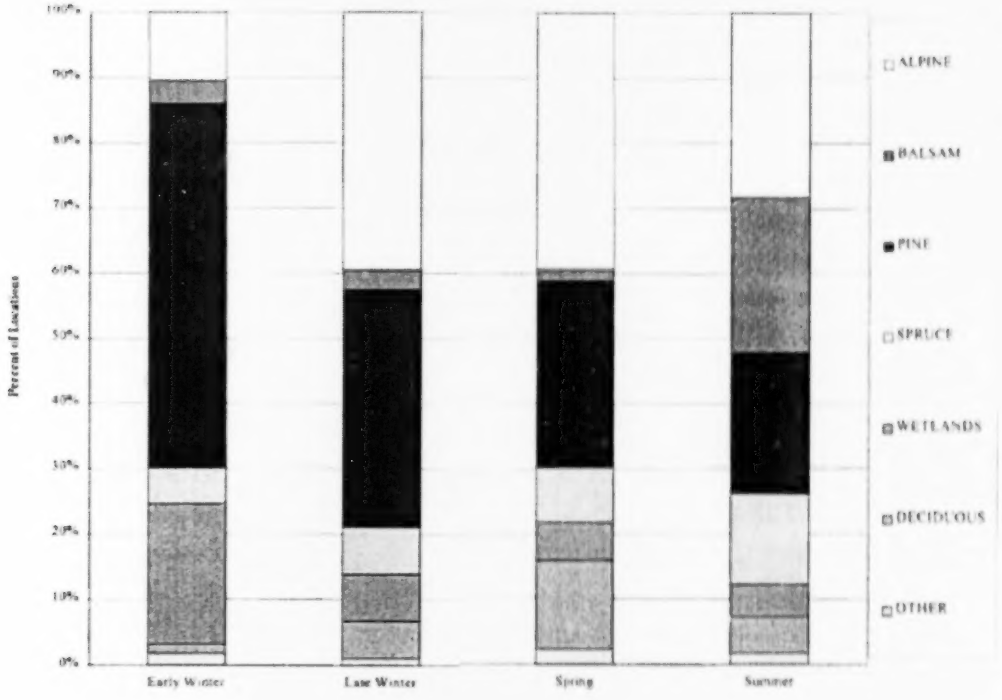

Figure 5. Percent of caribou locations in each habitat type during different seasons. Wolverine Caribou Herd, 1994-1997.

4.3.3 Aspect & Slope

Caribou also used significantly different aspects ($G = 13.9$, $df = 3$, $P = 0.003$) and slope classes ($G = 22.1$, $df = 6$, $P = 0.001$) among seasons. Caribou used cool aspects more frequently than warm aspects during all seasons, however, caribou used warm aspects more often during spring compared to other seasons (45% of locations) (Figure 6).

Caribou used flat and gentle slopes (<15%) extensively during all seasons, however, caribou confined their use to predominately flat areas during early winter and increased their use of moderate slopes (16-30%) during other seasons, particularly during late winter (Figure 7).

4.3.4 Distance to Nearest Wetland

Although many caribou were located and observed using non-forested wetlands (meadows, swamps, small lakes), caribou also used forested areas in close proximity to wetlands as well. The *sex x season* interaction indicated males and females were similar distances from wetlands during all seasons (ANOVA, $P = 0.288$). Although distance to the nearest wetland was similar for males and females ($P = 0.690$), seasonal differences were apparent ($P < 0.001$) (Table 4). Pairwise comparisons of seasons revealed caribou were significantly closer to wetland areas during early winter (< 500m) compared to all other seasons (Table 5).

4.4 Selection of Seasonal Home Ranges

Habitat composition within three of four seasonal home ranges differed from the study area. Late winter and spring seasonal ranges differed the most by having more alpine and less spruce dominated stands compared to the study area (Figure 8). In addition, late winter range contained less balsam whereas spring range contained more mixed deciduous forests compared to the entire study area. Proportions of habitats within early winter range were similar to the study area, however, significantly less balsam forests occurred in the early winter range. Summer habitat composition was virtually identical to the study area composition (Figure 8).

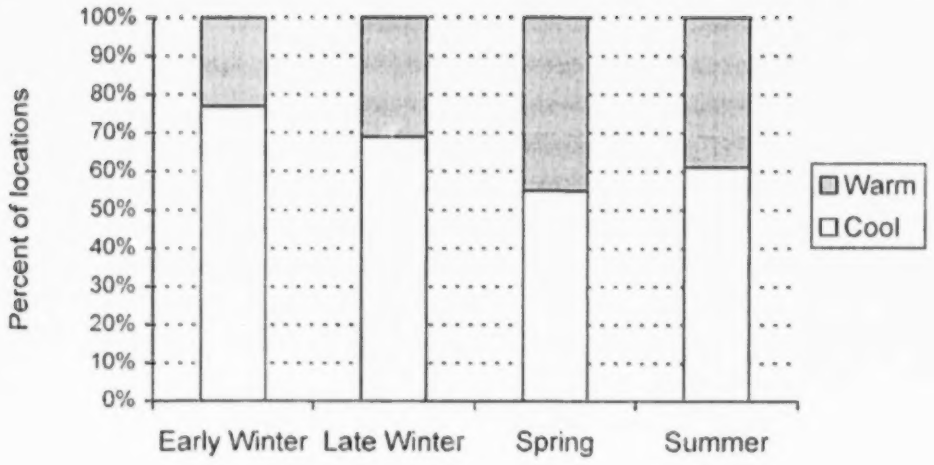

Figure 6. Percent of caribou locations on cool (271-135°) and warm (136-270°) aspects during different seasons. Wolverine Caribou Herd, 1994-1997.

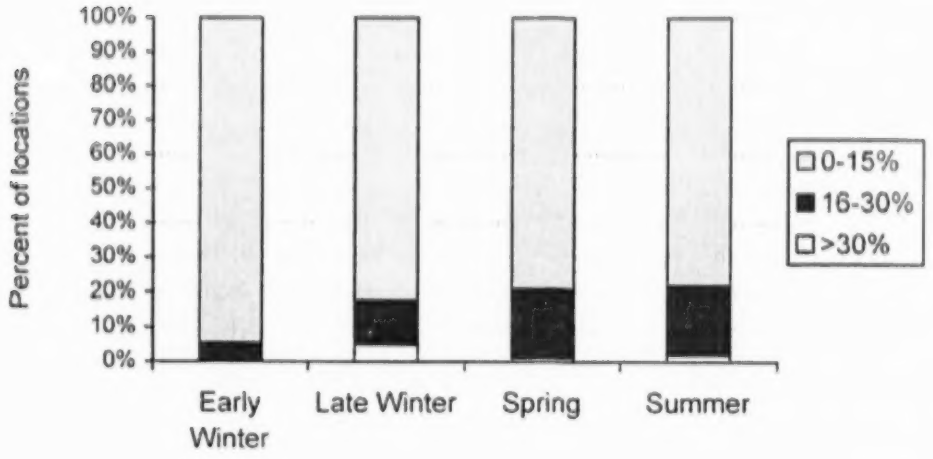

Figure 7. Percent of caribou locations in each slope class during different seasons. Wolverine Caribou Herd, 1994-1997.

Table 4. **Distance (m) to nearest wetland by sex and season. Wolverine Caribou Herd, 1994-97. Numbers are means ± 1SE. Number of radio-locations is shown in brackets.**

	SP	CA	SU	RU	EW	LW
Female	1,056 ±90 (110)	797 ± 66 (91)	1,142 ± 79 (25)	887 ± 227 (13)	461 ± 64 (146)	1,203 ± 98 (135)
Male	1,054 + 89 (53)	595 ± 99 (35)	758 ± 233 (9)	987 ± 267 (6)	507 ± 89 (74)	1,004 ± 143 (59)

SP= Spring; CA= Calving; SU =Summer; RU= Rut; EW= Early Winter; LW = Late Winter.

Table 5. **Pairwise comparisons of caribou distance to nearest wetland by season. Numbers are probabilities of post-hoc tests using bonferroni adjustments.**

	SP	CA	SU	RU	EW	LW
SP	1.00	1.00	1.00	1.00	1.00	1.00
CA	0.899	1.00	1.00	1.00	1.00	1.00
SU	1.00	1.00	1.00	1.00	1.00	1.00
RU	1.00	1.00	1.00	1.00	1.00	1.00
EW	0.00	0.00	0.002	0.001	1.00	0.00
LW	1.00	1.00	1.00	1.00	1.00	1.00

SP= Spring; CA= Calving; SU =Summer; RU= Rut; EW= Early Winter; LW = Late Winter.

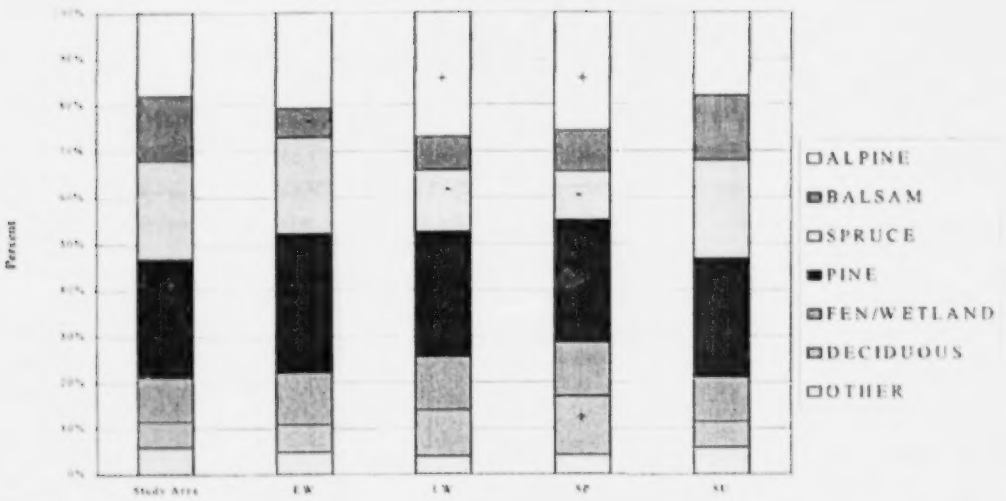

Figure 8. Habitat compositions within seasonal home ranges vs study area (annual composite herd home range). Wolverine Caribou Herd, 1994-97. + or - represents significant differences in habitat proportions between seasonal ranges and study area. $P < 0.05$ Z- statistic.

4.5 Selection of Forest Cover Types within Seasonal Home Ranges

4.5.1 Use-Availability

Caribou used habitats non-randomly during all seasons *($P < 0.001$)*. During early winter, caribou used lodgepole pine forests and fen/wetland areas significantly more than their availability (Table 6). Alpine/subalpine, spruce and mixed deciduous stands were used significantly less than expected. During late winter, caribou selected alpine/subalpine areas and used other habitats in proportion to their availability. However, selection for lodgepole pine as well as avoidance of spruce stands approached significance. During spring, caribou also selected alpine/subalpine areas and used most other habitats in proportion to availability. Balsam stands, however, were used significantly less then their abundance during this season. In contrast to spring, caribou used balsam stands significantly more than expected during summer. Caribou also used alpine/subalpine areas during summer significantly more than their occurrence. All other habitats were used in proportion to their availability (Table 6).

Table 6. Comparison of seasonal habitat availability and use (%) by radio-collared caribou in the Wolverine Herd. 1994-1997.

	Early Winter (*n* = 220)			Late Winter (n = 194)			Spring (n = 163)			Summer (n = 179)		
Habitat	Avail	Use		Avail	Use		Avail	Use		Avail	Use	
Alpine	20.6	10.4	-	27.0	39.7	+	25.6	41.1	+	18.1	28.5	+
Balsam	6.3	3.6		7.2	3.1		8.8	1.8	-	14.0	24.0	+
Spruce	20.7	5.5	-	13.3	6.7		10.4	4.3		21.2	13.4	
Pine	30.0	55.9	+	27.0	36.6		26.2	30.1		25.7	21.8	
Deciduous	6.0	1.4	-	10.1	5.8		12.8	14.1		5.6	5.6	
Fen/Wetland	11.2	21.4	+	11.6	7.2		11.6	6.1		9.6	5.0	
Other	4.8	1.8		3.9	0.0		4.1	2.5		5.8	1.7	

+ indicates use > availability; - sign indicates use < availability; no sign indicates use = availability

4.5.2 Selection Ratios and Habitat Rankings

The analysis of selection ratios also provided a relative ranking of seasonal habitat selection. During early winter, lodgepole pine forests and fen/wetland areas were the most preferred habitats while spruce leading and mixed deciduous stands were the least preferred (Table 7). Lodgepole pine forests and fen/wetland habitats (standardized ratios; 0.329, 0.326) were 3 times as likely to be selected by caribou during early winter as the next most likely habitat (balsam standardized ratio = 0.101). During late winter, alpine/subalpine habitats and mature/old pine forests were equally likely to be selected compared to other habitat types (Table 7). Similarly, caribou preferred alpine/subalpine as well as mature/old pine forests during spring, however, mixed deciduous stands were more likely to be used which differed from the winter seasons. Balsam leading stands and alpine habitats were the two most likely habitats to be selected during summer.

Table 7. Comparison between seasonal habitat selection ratios. Habitats are ranked left to right from most preferred to least preferred. Selection ratios connected by a horizontal bar are not significantly different at the 0.95 probability level.

	Habitat Ranks	Pine	> Wetland	> Balsam	> Alpine	> Other	> Spruce	> Deciduous
Early Winter	selection ratio	1.863	> 1.845	> 0.571	> 0.505	> 0.375	> 0.266	> 0.233
	standardized ratio	0.329	> 0.326	> 0.101	> 0.089	> 0.066	> 0.047	> 0.041
Late Winter	**Habitat Ranks**	Alpine	> Pine	> Wetland	> Deciduous	> Spruce	> Balsam	> Other
	selection ratio	1.470	> 1.356	> 0.643	> 0.569	> 0.500	> 0.431	> 0.250
	standardized ratio	0.282	> 0.260	> 0.123	> 0.109	> 0.096	> 0.083	> 0.048
Spring	**Habitat Ranks**	Alpine	> Pine	> Deciduous	> Other	> Wetland	> Spruce	> Balsam
	selection ratio	1.605	> 1.149	> 1.102	>0.610	>0.526	> 0.413	> 0.205
	standardized ratio	0.286	> 0.205	> 0.196	> 0.109	> 0.094	> 0.074	> 0.036
Summer	**Habitat Ranks**	Balsam	> Alpine	> Deciduous	> Pine	> Spruce	> Wetland	> Other
	selection ratio	1.714	> 1.575	> 1.000	> 0.848	> 0.632	> 0.521	> 0.293
	standardized ratio	0.260	> 0.239	> 0.152	> 0.129	> 0.096	> 0.079	> 0.045

4.6 Annual Variation In Habitat Use

Although small sample sizes precluded a statistical analysis of habitat selection by year, the following section provides a descriptive account of annual habitat use by season including annual variation in snow conditions.

4.6.1 Snow Conditions

Unfortunately, the snow station survey data only provides a general trend of snow conditions applicable to our late winter and spring seasons. No snow data were available for the early winter season (Nov-Dec). However, the January 1 measurement can be used as an indication of the total snow accumulation that occurred by the end of the early winter period (Dec. 30).

In general, these data indicated that the 94/95 winter was slightly below normal whereas the 95/96 and 96/97 winters were slightly above normal according to both the mid elevation (1160 m) snow station at Tsaydaychi Lake and the high (1500 m) elevation station at Germansen (Figure 9). In 94/95, snow packs were near normal (84/89 cm or 94%) by Jan 1, but were only 77% of normal by the end of January. During the above

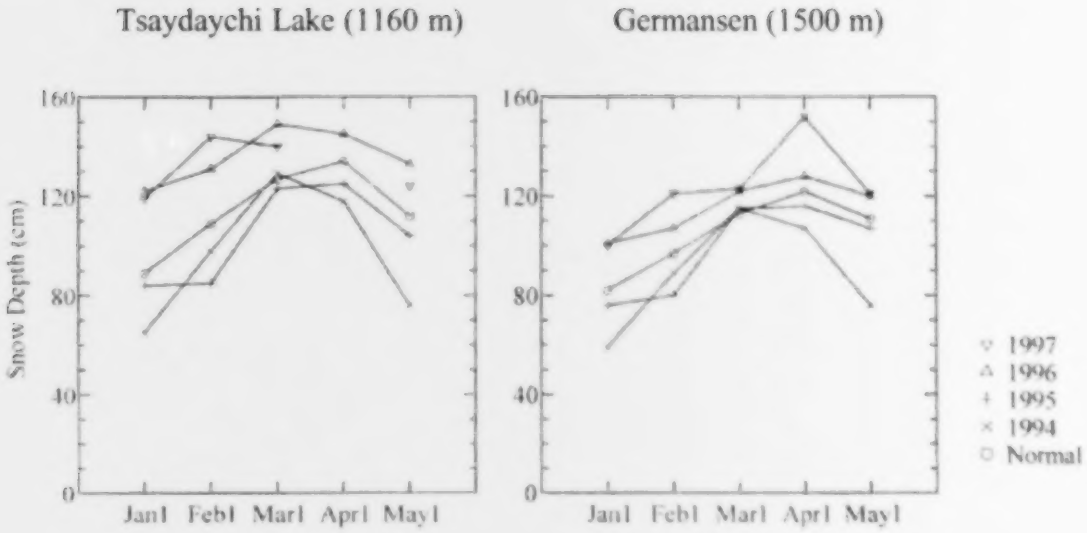

Figure 9. Total monthly snow accumulation for each year of the study compared to long term normals (14-34 years). Tsaydaychi Lake (1160 m) and Germansen (1500 m) snow stations.

normal snow years, snow depths were about 34% above normal by Jan 1. Overall, snow depths appeared to be slightly higher (about 20 cm) at the Tsaydaychi Lake station compared to Germansen (Figure 9).

4.6.2 Seasonal Shifts in Elevation Use

Although monthly elevation shifts were relatively consistent among years and between sexes, there was an indication of annual variation. In general, caribou descended to lower elevations twice each year, once during spring (Apr-May) and again in early winter (Nov-Dec) (Figure 10). In 95/96, following the below average snowfall winter of 94/95, both males and females descended to lower elevations during April compared to May in 94/95 and 96/97. Another difference in elevation use occurred during the below normal snowfall winter of 94/95, where both females and males did not ascend to higher elevations during Jan-Mar (Figure 10). In addition, male caribou did not appear to move as high as females during the 96/97 late winter, but instead remained in mid-elevation ESSF habitats (Figure

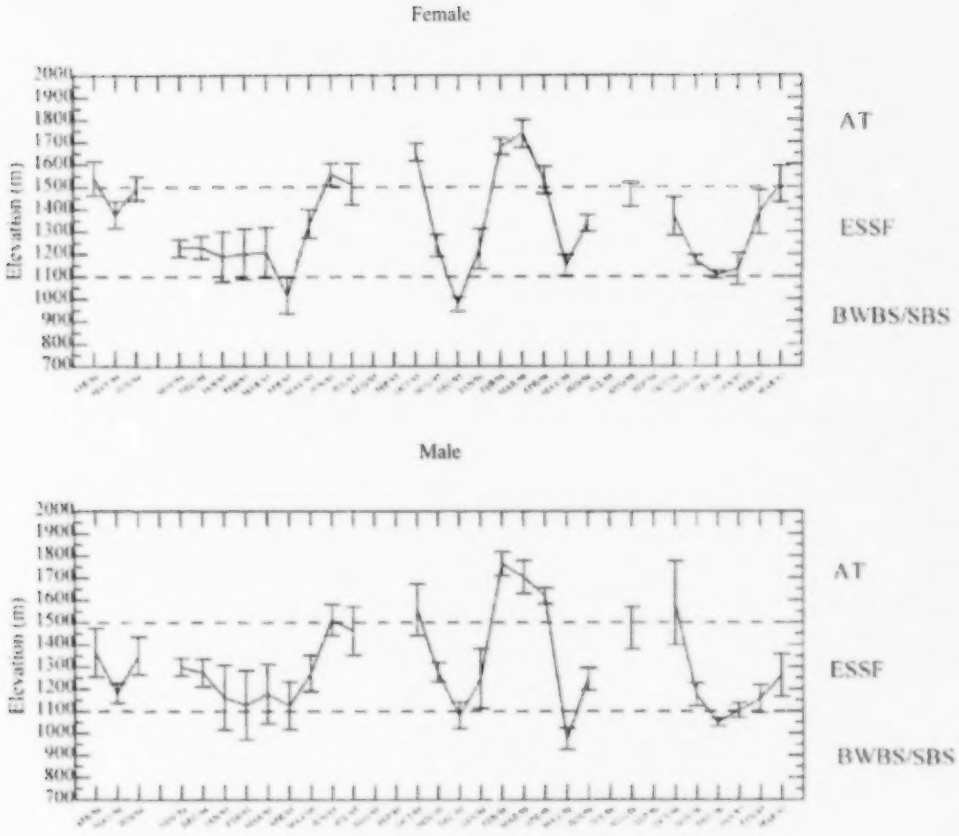

Figure 10. Mean monthly elevation use by female (n = 18) and male (n = 9) radio-collared caribou in the Wolverine Caribou Herd over the entire study period (Apr 1994- March 1997). Vertical bars represent 1SE. Dashed horizontal lines represent approximate biogeoclimatic zone elevation boundaries.

10). Overall, the most dramatic shifts in elevation use occurred during the 95/96 winter where both males and females descended to the lowest elevations in December and ascended to the highest elevations during Feb-Mar.

During the calving season, female caribou were located on average at 1,500 m elevation in 94/95 and 95/96. However, snowdepths in May 1996 were higher than in previous years, and caribou in 96/97 were located at much lower elevations (mean = 1,177 m) (Figure 11). These upper elevations corresponded to use of subalpine habitats dominated by balsam whereas the low elevation year corresponded to greater use of lodgepole pine forests.

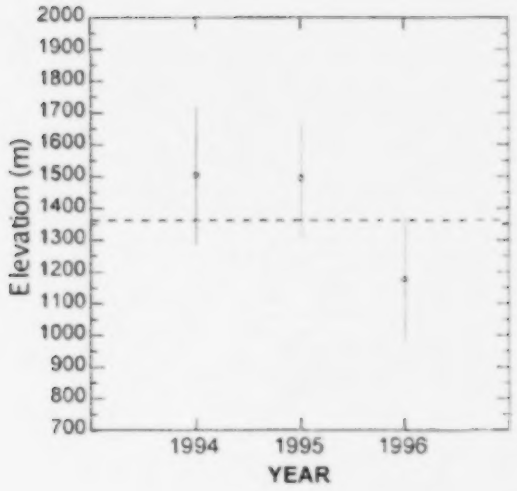

Figure 11. Mean elevation of female caribou in the Wolverine Caribou Herd during calving season (16 May - 15 June) each year. Circles represent means and bars represent 1 SD. Dashed line is average elevation during calving season over all 3 years. Sample sizes: 1994 = 9 radio-collared caribou (27 locations); 1995 = 7 radio-collared caribou (28 locations); 1996 = 11 radio-collared caribou (36 locations).

4.6.3 Early and Late Winter

Except for slightly less use of fen/wetlands in 95/96, caribou appeared to use habitats similarly during 95/96 and 96/97 early winters, where about two-thirds of the caribou locations occurred in mature and old lodgepole pine stands (Figure 12). In contrast to these two years, caribou used a greater variety of habitats during the 94/95 early winter period. In addition to lodgepole pine forests, caribou used fen/wetland habitats as well as alpine/subalpine areas to a greater extent during this year (Figure 12).

Late winter habitat use also appeared to vary slightly among years (Figure 13). During the below normal snowfall winter of 94/95, many caribou appeared to remain in mature lodgepole pine stands and used alpine and other upper elevation habitats less frequently compared to other years (Figure 13). In contrast, during 95/96 and 96/97, caribou used

Figure 12. Caribou habitat use by year during early winter (Nov-Dec). Wolverine Caribou Herd 1994-1997.

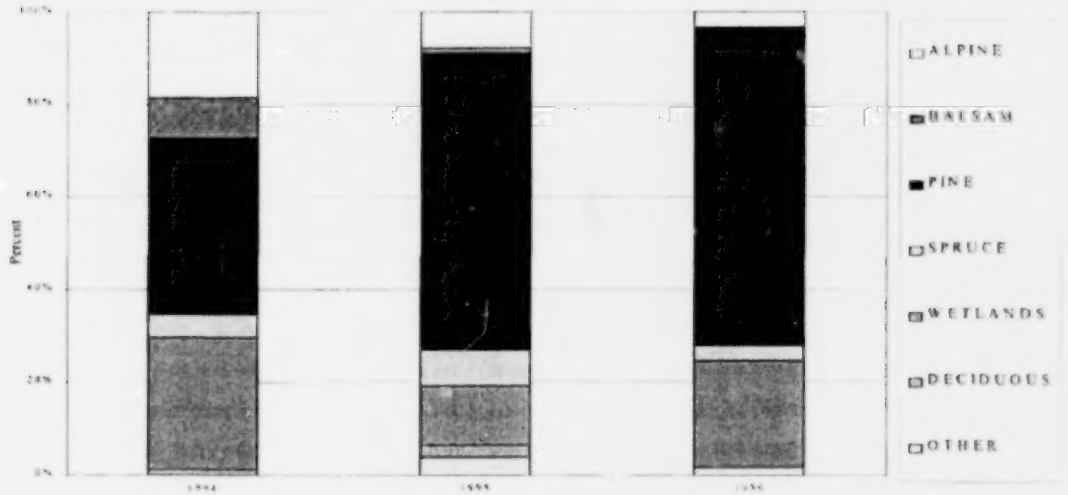

Figure 13. Caribou habitat use by year during late whiter (Jan-Mar). Wolverine Caribou Herd. 1994-1997.

upper elevation habitats including alpine, balsam and spruce leading stands more frequently.

4.6.4 Spring and Summer

During the 95/96 spring, caribou appeared to use lower elevation habitats (e.g., pine, mixed deciduous forests) more frequently compared to either spring periods of 94/95 and 96/97 (Figure 14). Overall, caribou used summer habitats consistently among years (Figure 15). Caribou concentrated their use in alpine and balsam leading stands during all years, however, in 96/97 about 20% fewer locations were recorded in these higher elevation habitats compared to the two previous years. Instead, caribou used more lodgepole pine and spruce dominated forests (Figure 15).

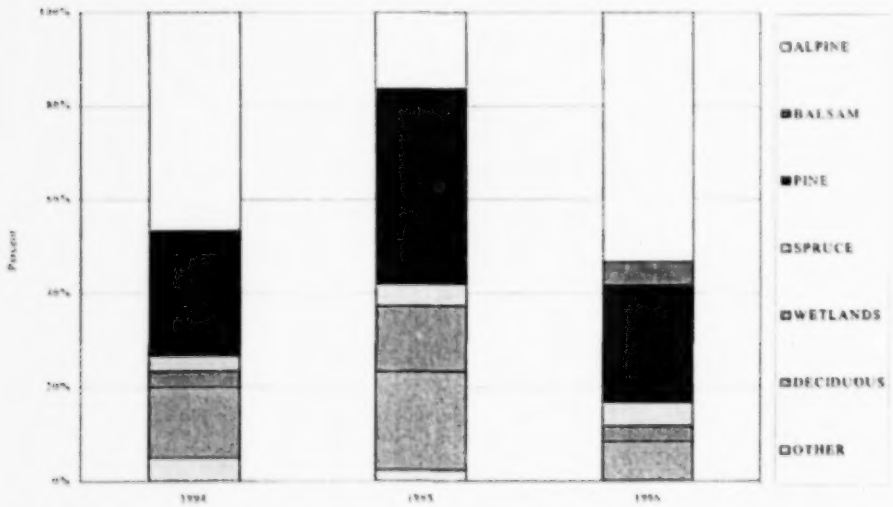

Figure 14. Caribou habitat use by year during spring (Apr. 1- May 15). Wolverine Caribou Herd. 1994-1997.

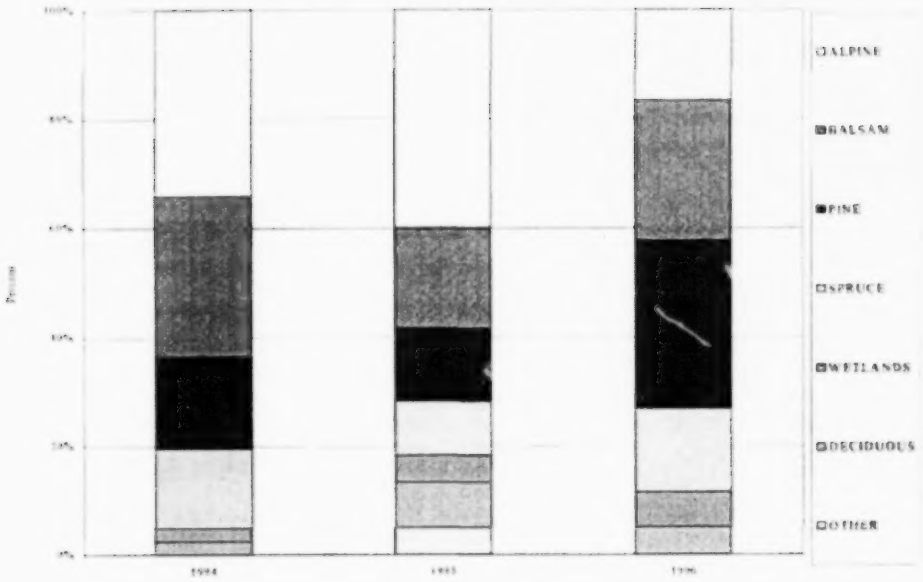

Figure 15. Caribou habitat use by year during the summer (June-Oct). Wolverine Caribou Herd 1994-1997.

4.7 Population Characteristics

4.7.1 Mortality

Seven female and 5 male radio-collared caribou died during the 3 year study (Table 8). Half of the animals died in the spring/summer, and half in the early/late winter periods. All but 2 of the animals died in middle or low elevation forested habitats. The mean elevation was 1,125 ± 268 m for female mortalities, and 1,330 ± 220 m for males. There was no significant difference between the mean elevations (t = -1.400, df = 10, P = 0.192).

Mortality sites of 2 females and 1 male were investigated; evidence at the sites of the females suggested wolf predation as the primary cause of death. A bull caribou captured in 1991 (#544) was observed during a tracking flight in 1996 being attacked at the hind

Table 8. Radio-collared female and male caribou mortalities in the Wolverine Herd between April 1994 and March 1997.

I.D#	Sex	Capture Year	Mortality Date Year	Month	Season	Elevation (m)	Habitat
753[1]	F	1995	1996	May	Spring	900	Meadow
761[1]	F	1996	1996	May	Spring	875	Pine/Spruce forest
433	F	1991	1994	Jun-Nov	Summer	1225	Balsam/Spruce forest
1893	F	1992	1995	Jul-Oct	Summer	1650	Alpine
312	F	1991	1995	Dec	Early winter	1200	Pine forest
151	F	1996	1997	Feb-Mar	Late winter	1050	Pine/Spruce forest
515	F	1992	1996	Mar-Apr	Late winter	975	Frozen lake
544[1,2]	M	1991	1996	Apr	Spring	1475	Spruce/Balsam forest
921	M	1996	1996	Aug-Oct	Summer	1400	Balsam/Spruce forest
630	M	1994	1994	Dec	Early winter	1275	Balsam/Spruce forest
772[3]	M	1995	1996	Jan	Late winter	975	Pine forest
642	M	1994	1996	Mar-Apr	Late winter	1525	Subalpine

[1] Sites investigated on the ground
[2] Attacked and killed by female wolverine
[3] Appeared to die of old age

end by a female wolverine (verified by the radio-collar she was wearing as part of an ongoing study of wolverines in the area). A site investigation the subsequent day found the wolverine still at the site, and the bull caribou dead.

The fate of an additional bull was surmised to be "old age". During capture in November 1995, the large bull was noted to be missing many teeth (those present were very worn), and he put up little resistance to restraint during collaring. The bull was located by fixed-wing in the same immediate area on four consecutive flights between 9 December and 5 January 1996, before finally emitting a mortality signal from the radio-collar. No tracks of other caribou or predators were observed in that area on any of the flights.

4.7.2 Population Density

The maximum area that radio-collared caribou in the Wolverine Herd used during the 3 year study was 4,014 km^2 (multi-annual herd home range). The Wolverine Herd was estimated at 361 animals during a March 1996 mark-resight winter inventory (225-497 caribou, applying 95% confidence intervals; Wood 1998). The density of caribou in the Wolverine Herd is estimated at 0.09 caribou/km^2 (range 0.06 to 0.12) assuming that only caribou that wintered in the census area used the 4,014 km^2 area. The density of caribou in the herds'multi-annual late winter range (1,198 km^2) was 0.30 caribou/km^2 (range 0.19 to 0.41).

5.0 DISCUSSION

Although collared caribou in the Wolverine Herd used many of the same forest cover types throughout the year, clear seasonal selection was demonstrated for certain forest cover types. Selection was strongest during early winter when caribou concentrated their activity in mature and old lodgepole pine forests where they were presumably able to crater for terrestrial lichens as well as forage on any available arboreal lichens. These results are consistent with other woodland caribou (northern ecotype) habitat studies conducted in British Columbia (Hatler 1986, Cichowski 1989) and Alberta (Edmonds 1988) where caribou use pine dominated forests extensively during winter. Although this study did not identify specific feeding habitats within lodgepole pine forests, Cichowski (1989) found woodland caribou used primarily drier, less productive lodgepole pine forests that supported abundant terrestrial lichens *(Cladina* spp., *Cladonia* spp.).

The use of lodgepole pine forests during early winter differs however from the patterns of use observed by the Wolverine Herd during Phase 1 (1991-93; Wood and Terry 1999). During the early winters of 1991-93, caribou were more likely to select windswept alpine ridges rather than forested habitats (including lodgepole pine). Alpine habitats were used extensively by collared caribou during Phase 1 in all seasons except spring when forested habitats were also used. However, the small number of early winter locations obtained for the Wolverine Herd during Phase 1 *(n* = 12 caribou and 40 locations), provided relatively weak evidence of habitat selection patterns during early winter. Although additional radio-collared caribou as well as snow conditions may have accounted for this difference, closer inspection of the data did not provide a clear explanation. That is, 9 of 12 radio-collared caribou monitored during Phase 1 were the same animals monitored

during Phase 2, but selected primarily pine forests during this study. Secondly, both Phases included one winter with below normal snow accumulation when caribou are presumably able to stay in low elevation lodgepole pine forests to crater for terrestrial lichens. However, caribou used lodgepole pine forests more frequently only during the low snow winter of this study and not during Phase 1. Once again, it should be emphasized that small sample sizes obtained during Phase 1 hamper interpretations. Of course, other factors (e.g., predators,) may have also influenced habitat selection patterns during these years.

Caribou used lodgepole pine forests consistently among years, however, many caribou appeared to remain in mature pine stands during the 94/95 winter and reduced their use of alpine and other upper elevation habitats. Rather than ascending to the Wolverine or Germansen Ranges where they typically spend late winter, caribou wintered in the Germansen River and Jackfish Creek areas. The lower snow accumulations over the winter of 94/95 may have allowed caribou to remain in lower elevation pine stands to crater for terrestrial lichens. In contrast, caribou used upper elevation habitats including alpine, balsam and spruce leading stands more frequently during the winters of 95/96 and 96/97 when snow packs were slightly above normal. This suggests that winter snow conditions may influence caribou habitat selection patterns. Because both high and low elevation habitats were used during the late winter of 94/95, also suggests there is some individual variation among caribou.

In addition to lodgepole pine forests, collared caribou also selected fen/wetland areas during early winter (1994-97). Many caribou were also located in lodgepole pine forests immediately adjacent to wetland areas; caribou were significantly closer (< 500 m) to wetland areas during early winter than in any other season. Both the use and close proximity of caribou to fen/wetland areas reflects the mosaic and spatial distribution of lodgepole pine forests and wetlands that occur on the plateau west of Squawfish Lake (Figure 1, Appendix 2). Although this study did not address specific feeding habitats, woodland caribou in Alberta also make extensive use of peatland complexes and forested bogs that support terrestrial lichens *(Cladina* spp.) (Bradshaw *et al.* 1995). Whether caribou use wetland complexes for the food sources (e.g., sedges, terrestrial and/or arboreal lichens, water, minerals) they provide, or for some predator vigilance reason is not clear from these data. However, occasional ground inspection of cratering sites suggested caribou were feeding primarily on sedges when they were in wetland areas and on terrestrial lichens when in adjacent pine forests.

Caribou used mixed deciduous stands most frequently during spring. The use of mixed deciduous forests likely reflects areas that provide early "green up" vegetation, as many of these stands are situated on warm south-facing aspen slopes. Although other woodland caribou habitat use studies have not specifically reported on the use of aspen forests, some mountain ecotype have shown caribou typically descend to lower elevations during spring, particularly during the month of May (Seip 1990, 1992; Terry 1993).

During summer, female caribou used high elevation balsam stands at or near treeline with rocky outcrops. Use of high elevation ESSF stands as calving/summer range is consistent with other studies of northern caribou (Cichowski 1989) as well as mountain caribou (Simpson and Woods 1987, Seip 1992, Terry 1993, McLellan and Flaa 1994). Female caribou appeared to calve at lower elevations during the spring of 96/97 subsequent to the winter with slightly above normal snow depths (and high snowpack in May). Although the reasons for caribou calving locations at lower elevations is not clear from this data, possible explanations include limited access to typical calving sites, or a response to the late lying snows in the alpine and subalpine which did not provide cryptic calving sites (increased vulnerability) and/or available food sources (Bergerud *et al.* 1984).

In this study, caribou density estimates were between 0.06 - 0.12 caribou/km^2, which are slightly higher than other densities reported for caribou populations that space out in alpine areas during summer and where wolves are not exploited (Bergerud 1992, Seip and Cichowski 1996).

6.0 MANAGEMENT RECOMMENDATIONS

- During early winter, caribou selected mature lodgepole pine forests, especially those that occur west of Squawfish Lake encompassing Gillis Creek and the Klawli River drainages. These forests warrant habitat protection and/or special management (e.g., alternative silvicultural systems) to provide terrestrial lichen feeding habitats over the long term. Although pine-lichen forests are a fire-dependent ecosystem that requires periodic disturbance to maintain terrestrial lichens, it should be emphasized that our knowledge regarding the effects of logging on terrestrial lichens is limited. Therefore, to ensure suitable winter habitat is maintained for caribou, a comprehensive caribou management strategy needs to be developed. Management strategies should address seral stage objectives that ensure adequate supplies of pine-lichen forests are available throughout a rotation, appropriate silvicultural systems, forest health (mountain pine

beetle), fire management, as well as road access management strategies. In addition, these management strategies need to be integrated with the habitat selection and seasonal movement patterns described in this study. The information presented here can also be used to develop preliminary habitat suitability models, which could provide further interpretations of the Terrestrial Ecosystem Mapping (TEM) project underway in the Mackenzie Forest District.

- The telemetry and distance to nearest wetland data suggests connectivity between mature lodgepole pine stands and fen/wetland areas should be maintained using *Forest Ecosystem Networks* (FENs), particularly around the wetland complexes located on the Squawfish Plateau.

Suggested Research Projects

- Further research (e.g. ground inspection, trailing studies) is required to determine why riparian fen/wetland complexes are being used during early winter. Wetland classification (FPC) and mapping of xeric communities that may contain terrestrial lichens may provide further identification of specific wetland types. The *Terrestrial Ecosystem Mapping* (TEM) project currently underway (Madrone Consultants) should also provide information on the relative distribution of potential winter feeding ecosystems (e.g., Pine-crowberry-cladina) as well as non-forested habitats (e.g., fen/wetlands). These maps should provide a more refined distribution of caribou winter habitat needed to guide habitat protection efforts during landscape-level and operational planning.

- To ensure winter foraging habitats are maintained, the development of caribou habitat supply models is strongly recommended to determine the spatial and temporal availability of pine-lichen forests under different forest management regimes.

- Further research is also required to determine how terrestrial lichens respond to various silvicultural treatments (e.g., alternative silvicultural systems, site preparation, commercial thinning etc).

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APPENDIX 1.0

Capture and relocation dates of radio-collared caribou

Capture Dates: Feb 6/7/8, 1991 Mar 19, 1992 Jan 12, 1993 March 29, 1994 November 2, 1995 February 29, 1996 March 1, 1996																				WOLVERINE HERD									
Capture Date		Jan-93	Feb-95	Mar-96	Mar-96	Mar-96	Feb-91	Feb-91	Feb-91	Feb-91	Mar-92	Mar-92	Mar-92	Feb-91	Mar-94	Mar-94	Mar-94	Mar-94	Mar-94	Nov-95	Feb-96	Nov-95	Nov-95	Nov-95	Nov-95	Nov-95	Feb-96	Mar-92
Capture Locn		gillis	wolv r	wolv N	germ r	wolv r	wolv s	man lk	wolv 5	man lk	wolv n	wolv s	wolv s	wolv lk	wolv s	wolv s	wolv s	wolv n	wolv s	klawli	wolv r	klawli	klawli	gillis Cr	gillis Cr	gillis Cr	wolv r	wolv m
Sex		F	F	F	F	M	F	F	F	F	F	F	F	M	M	M	M	M	M	F	F	M	F	F	M	F	M	F
Age		2-3	adult	2	adult	adult	small	2-3		1-2	2-3	2-3	4+		2-3	2	5-6	2-3	4	2-3	adult	6+	yrlg	2-3	4-5	2	adult	3+
Caribou ID #		110	121	131	151	180	312	372	433	443	464	515	524	544	610	620	630	642	650	753	761	772	781	792	901	912	921	1893
94/95	9-Apr	x					x	x	x	x	x	x	x	x	x	x	x	x	x									x
	18-Apr	x					x	x	x	x	x	x	x	x	x	x	x	x	x									x
	28-Apr	x					x	x	x	x	x	x	x	x	x	x	x	x	x									x
	8-May	x					x	x	x	x	x	x	x	x	x	x	x	x	x									x
	19-May	x					x	x	x	x	x	x	x	x	x	-	x	x	x									x
	2-Jun	x					x	x	x	x	x	x	x	gen	x		x	x	x									x
	10-Jun	x					x	x	x	x	x	x	x	x	x	-	x	x	x									x
	12-Nov	-					gen	x	dead	x	gen	x	x	x	x	-	gen	gen	x									x
	20-Nov	x					x	x		x	gen	x	x	x	x	-	gen	gen	x									x
	28-Nov	x					x	x		x		x	x	x	x	-			x									
	3-Dec	x						x		x	x	x	x	x	x	-	x	x	x									x
	9-Dec	gen					x	x		gen	gen	x	x	gen	x	-	dead	x	x									x
	13-Dec	x					gen	-		x		x	x	x	x	-			x									
	20-Dec	x					gen	x		x	gen	x	x	x	x			gen	x									
	31-Dec	x					x	-		x	x	x	x	x	x	-		x	x									x
	19-Jan	x					x	-		x	x	x	x	x	x			x	x									x
	26-Jan	x					x	-		x	x	x	x	x	x			x	x									x
	2-Feb	x					x	-		x	x	x	x	x	x			x	x									x
	27-Feb	x					x	-		x	x	x	x	x	x			x	x									x
	12-Mar	x					x	-		x	x	x	x	x	x			x	x									x
	25-Mar	x					x	-		x	x	x	x	x	x			x	x									x
95/96	10-Apr	x					x	-		x	x	x	x	x	x			x	x									x
	17-Apr	x					x			x	x	x	x	x	x			x	x									x
	26-Apr	x					x			x	x	x	x	x	x			x	x									x
	9-May	-					x			x	x	x	x	x	x			x	x									x
	18-May	x					x			x	x	x	x	x	x			x	gen									x
	25-May	x					x			x	x	x	x	x	x			x										x
	31-May	x					x			x	x	x	x	x	x			x	x									x
	7-Jun	x					x			x	x	x	x	x	x			x	x									x
	14-Jul	x					x			x	x	x	x	x	x			x	x									x
	8-Oct	x					gen			-	x	x	gen	x	x			x	gen									dead
	1-Nov	x					x			-	x	x	x	x	x			x	x									
	10-Nov	x					x				x	x	x	x	x			x	x	x		x	x	x	x	x		
	29-Nov	x					x			-	x	x	x	x	x			x	x	x		x	x	x	-	-		
	9-Dec	x					dead				x	x	x	x	x			x	x	x		x	x	x	x	x		
	22-Dec	x									x	x	x	x	x			x	x	x		x	x	x		x		
	30-Dec	x									x	x	x	x	x			x	x	x		x	x	x		x		
	5-Jan	x									x	x	x	x	x			x	x	x		dead	x	x		x		
	17-Jan	x									x	x	x	x	x			x	x	x			x	x		x		
	2-Feb											x	x	x	x			x	x	x				x		x		
	20-Feb	x									x	x	x	x	-			x	x	x			x	x		x		
	7-Mar				x								x					x					x	x				
	17-Mar	x		x		x					x	x		x	x				x	x	x					x	x	

Capture Dates: Feb 6/7/8, 1991 Mar 19, 1992 Jan 12, 1993 March 29, 1994 November 2, 1995 February 29, 1996 March 1, 1996

WOLVERINE HERD

Capture Date		Jan-93	Feb-96	Mar-96	Mar-96	Mar-96	Feb-91	Feb-91	Feb-91	Feb-91	Mar-92	Mar-92	Mar-92	Feb-91	Mar-94	Mar-94	Mar-94	Mar-94	Mar-94	Nov-95	Feb-96	Nov-95	Nov-95	Nov-95	Nov-95	Nov-95	Feb-96	Mar-92
Capture Locn		gills	wolv r	wolv N	germ r	wolv r	wolv s	man fk	wolv s	man fk	wolv n	wolv s	wolv s	wolv fk	wolv s	wolv s	wolv s	wolv n	wolv s	klawli	wolv r	klawli	klawli	gills Cr	gills Cr	gills Cr	wolv r	wolv m
Sex		F	F	F	F	M	F	F	F	F	F	F	F	M	M	M	M	M	M	F	F	M	F	F	M	F	M	F
Age		2-3	adult	2	adult	adult	small	2-3		1-2	2-3	2-3	4+		2-3	2	5-6	2-3	4	2-3	adult	6+	yrlg	2-3	4-6	2	adult	3+
Caribou ID #		110	121	131	151	180	312	372	433	443	464	515	524	544	610	620	630	642	650	753	761	7/2	781	792	901	912	921	1893
96/97	11-Apr	x	x	x	x	x					x	dead	x	dead	x			dead	x	x	x		x	x			x	
	19-Apr	x	x	x	x	x					x		x		x					x	x		x	x		x	x	
	30-Apr	-	x	x	x	x					x		x		x				x	-	x		x	x		x	x	
	10-May	x	x	x	x	x					x		x		x				x	x	x		x	x		x	x	
	22-May	x	-	x	x	x					x		x		-				x	dead	x		x	x		x	x	
	29-May	x	gen	x	x	x					x		x		x				x		dead		x	x		x	x	
	11-Jun	x		x		x					x		x						x				x	x		x	x	
	12-Jun	x		x									x											x		x		
	13-Jun				x																		x					
	20-Jun	x	x	x	x	x					x		x						x				x	x		x	x	
	14-Aug	-	x	x	x	x					x		x		x				x				-	x		x	x	
	17-Oct	gen	x	gen	x	gen					gen		x		x				x				x	gen		gen	dead	
	1-Nov	-	x	x	x	x					x		x		x				x				x	x		x		
	15-Nov	-	x	x	x	-					x		x		x				x				x	x		x		
	27-Nov	-	x	x	x	-					x		x		x				x				x	x		x		
	5-Dec	-	x	x	x	-					x		x		x				x				x	x		x		
	12-Dec		x	x	x						x		x		x				x				x	x		x		
	21-Dec		x	x	x						x		x		x				x				x	x		x		
	3-Jan		x	x	x						x		x		x				x				x	x		x		
	15-Jan		x	-	x						x		x		x				x				x	-		x		
	31-Jan		x	x	x						x		x		x				x				x	x		x		
	4-Feb		x	x	x						x		x		x				x				x	x		x		
	19-Feb		x	x	x						x		x		x				x				x	x		x		
	5-Mar		x	x	dead						x		x		x				x				x	x		x		
	20-Mar		x	x							x		x		x				x				x	x		x		

LEGEND:

x = animal located during tracking flight

"-" = animal not located during tracking flight

dead = collar emitting mortality signal

gen = general location obtained, no precise coordinates

empty cell = animal not tracked, dead, or not yet collared

APPENDIX 2.0

Forest cover types within the multi-annual home range of the Wolverine Caribou Herd (1994-1997)

Habitat Classes